

# Planting six tree species on soda-saline-alkali soil

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**Abstract** Populus simonigra, Salix matsudana, Ulmus pumila, Populus nigra, Acer negundo, Fraxinus mandshurica, Tamarix chinensis, Hippophae rhammoides, Syringa onlata were planted on the soda-saline-alkali. The soil had pH 8.5~9.6, salinity 0.1%~0.3%, sodiumionized ratio 16%~51% and normality ratio of saline base  $\text{Na}^+ /(\text{Ca}^{++} + \text{Mg}^{++}) > 4$ . Populus simonigra grows very well on the all kinds of soda-saline-alkali soils except on the alkali sport with the worst soil condition and showed a high wood increments and biomass. After 9 a, the volume can reach 100 m<sup>3</sup>/hm<sup>2</sup>, and the above-ground biomass can reach 28.7 t/hm<sup>2</sup>.

**Key words:** Planting, Forest plantation, Soda-saline-alkali soil, Productivity

## Introduction

There are about 2,000,000 hm<sup>2</sup> of soda-saline-alkali soil in Songlun plain in Heilongjiang (Shen 1998). It is distributed mainly in Zhaodong, Zhaozhou, Zhaoyuan, Anda, Daqing, Duerbute and other counties and cities. Formerly, there were no trees on soda-saline-alkali soil. Crops can not grow on such soils. Planting trees on these soils might improve on its quality (Ling *et al* 1982). To study planting on soda-saline-alkali soil has significance for establishing protective plantation system of grassland and establishing perfect protective plantation system of farmland in Heilongjiang Province.

## Site and methodology

The study site is located at 10 km west of Zhaodong city between the communes of Xincheng and Xiangyang. Zhaodong has a temperate continental monsoon climate. The mean annual temperature is 3.4 °C. The accumulated temperature above 10 °C is 2791 °C, with a 140 d frost-free period. The average annual precipitation and evaporation are 464 mm and 1551 mm respectively. The mean wind velocity is 3.6 m/s. Main soil in this area is soda-saline-alkali soil of  $\text{NaHCO}_3$  and  $\text{Na}_2\text{CO}_3$  as main components. 4 kinds of soils were presented in the study site, which were: alkalinized meadow soil, deep columnar soda-meadow-alkali soil, medium columnar soda-meadow-alkali soil and shallow columnar soda-meadow-alkali

soil. The chemical properties of these soils are presented in Table 1. The normality ratios of saline base  $\text{Na}^+ /(\text{Ca}^{++} + \text{Mg}^{++})$  under plantations (profile 1 and profile) are 5.3, 11.5, 4.7, 8.2, 1.1, 9.1, 18.5 and 10.0 respectively. pH-value ranged from 8.5 to 9.6, sodiumionized ratio 16%~51 % and salinity 0.1%~0.3 %. There are only few woody plants growing naturally in this area. *Lespedeza hedysaroides* var. *subsericea* was found on the study site, but there are 65 species of herbs on the site, including saline resistance plants such as *Suaeda glauca*, *Artemisia anethifolia* and *Puccinellia tenuiflora*. Alkali resistance plants such as *Anearopidium chinense* were also presented. Meadow and grassland plants were *Chloris virgata*, *Saussurea amara*, *Artemisia argyi* and *Plantago siatica*.

In 1990, soils and vegetation were surveyed. 4 soil profiles (1 m × 1 m × 1.6 m) were dug and 24 soil samples were taken. Eleven permanent plots were inventoried. The stand attributes of the plots are presented in Table 2. The size of the single plot was 0.06 hm<sup>2</sup> (20 m × 30 m). Eighteen trees of stem analysis and 4 plots of above-ground biomass and leaf area were measured.

## Results and analysis

### Tree growth on the same soil

The stem analysis of mean tree for 6 tree species was measured on the deep columnar soda-meadow-alkali soil on plot 2 (see Table 3).

Table 3 shows that for the same soil condition and same silviculture technique, the order of DBH incre-

ment was *P. somonigra* > *U. pumila* > *S. matsudama* > *P. simonii* × *canadensis* > *A. negundo* > *F. mandshurica*. The order of height increment was *P. simonigra* > *P. simonii* × *canadensis* > *S. matsudama* > *A. negundo* > *F. mandshurica*. The order of volume is *P. simonigra* > *S. matsudama* > *U. pumila* > *P. simonii* × *canadensis* > *A. negundo* > *F. mandshurica*.

#### Growth of *P. simonigra* on different soils

DBH, height and volume data for *P. simonigra* show that its growth on the medium columnar soda-meadow-alkali soil was less than on the alkalinized meadow soil and deep columnar soda-meadow-alkali soil. Among 3 kinds of soils, medium columnar soda-meadow-alkali soil had the worst conditions. During the first 7 years, the tree increment on the alkalinized meadow soil was larger than that on the deep columnar soda-meadow-alkali soil. But after 7 years, it was

opposite. Both had similar silviculture measures. The plantation on the deep columnar soda-meadow-alkali soil was the mixed stand of 6 tree species and several kinds of shrubs. This mixture of trees and shrubs might have improved the physical and chemical properties of the soil.

#### The biomass and leaf area of *P. simonigra*

To study the productivity and growth potentiality, the above-ground biomass and leaf area of 4 plots for *P. simonigra* were measured. The results are presented in Table 5

Biomass of stem, branch, leaf and bark or leaf area index were highest on alkalinized meadow but lowest on deep columnar soda-meadow-alkali soil. For plot 6, although the soil condition is not very good, the biomass is also very high by fertilizing with organic manure.

**Table 1. The chemical properties of soils unit: me/100g soil**

Pro-file	Depth /cm	SO <sub>4</sub> <sup>=</sup>	CO <sub>3</sub> <sup>=</sup>	HCO <sup>-</sup>	CL <sup>-</sup>	K <sup>++</sup> + Na <sup>+</sup>	Ca <sup>++</sup>	Mg <sup>++</sup>	pH	SS*	Na <sup>+</sup>	SR**	Soil name
1	0-20	0.22	0.08	0.96	0.08	1.09	0.20	0.06	8.55	0.22		9.22	Alkalized meadow soil
	20-48	0.10	0.37	1.03	0.28	1.59	0.12	0.06	8.80	0.20		18.97	
	48-79	0.10	0.49	0.88	0.17	1.42	0.10	0.12	9.05	0.14		15.74	
	79-106	0.10	0.29	0.88	0.11	0.98	0.20	0.16	8.90	0.11			
	106-150	0.16	0.21	0.78	0.12	0.90	0.20	0.16	8.85	0.11			
2	0-12	0.12	0.21	1.05	0.17	1.30	0.20	0.04	8.68	0.17	1.26	16.57	Deep columnar soda-meadow-alkali soil
	12-35	0.84	0.33	1.01	0.36	2.33	0.08	0.12	8.68	0.20	2.39	22.79	
	35-100	0.12	0.37	0.94	0.19	1.34	0.16	0.12	9.00	0.15	1.32	15.94	
	100-150	0.20	0.21	0.79	0.18	1.05	0.24	0.08	8.85	0.12	1.04		
3	0-12	0.08	0.00	0.60	0.12	0.60	0.40	0.16	8.30	0.11	0.57	0.52	Medium columnar soda-meadow-alkali soil
	12-35	0.04	1.15	1.89	0.31	3.07	0.12	0.20	9.20	0.29	2.90	43.54	
	35-110	0.20	2.13	1.39	0.26	3.79	0.08	0.12	9.60	0.27	3.69	51.40	
	110-150	0.04	0.66	1.42	0.16	2.07	0.08	0.12	9.10	0.19	2.01		
4	0-7	0.16	0.33	1.07	0.20	1.37	0.16	0.16	8.75	0.17		15.63	Shallow columnar soda-meadow-alkali soil
	7-26	0.36	0.70	1.70	0.11	2.62	0.16	0.12	9.10	0.33		33.69	
	26-51	0.64	1.07	1.29	0.17	2.97	0.08	0.12	9.20	0.26		31.77	
	51-105	0.32	0.25	0.88	0.10	1.31	0.08	0.16	8.90	0.15			
	105-150	0.16	0.16	0.01	0.13	1.03	0.08	0.16	8.75	0.13			

Note : \* SS= Salinity solubility; \*\*SR= Sodiumionized ratio.

**Table 2. Stand attributes of 11 Plots**

Plot No	Stand age /a	Average DBH /cm	Mean height /m	Dominant height /m	Number of trees tree hm <sup>-2</sup>	Stand volume /m <sup>3</sup>
5	8	5.9	5.9	7.1	1150	9
9	10	9.5	9.7	10.9	1483	51
6	10	10.7	9.3	11.2	1700	77
4	11	7.6	7.3	11.2	1683	24
7	9	9.0	8.0	9.3	3373	100
11	8	8.2	7.1	8.3	1050	25
1	11	10.4	11.2	11.3	1333	56
8	11	10.7	10.2	10.7	1770	81
10	9	3.8	3.3	5.3	8462	24
3	10	5.7	6.0	9.1	1683	23
2	11	11.0	11.5	12.3	1667	45

**Table 3. Tree increments on the deep columnar soda-meadow-alkali soil**

Year	<i>Populus simonigra</i>			<i>Salix matsudama</i>			<i>Acer negundo</i>		
	Diameter /cm	Height /m	Volume /m³	Diameter /cm	Height /m	Volume /m³	Diameter /cm	Height /m	Volume /m³
1986	9.7	8.6	0.0282	5.7	4.5	0.0061	3.9	3.5	0.0033
1987	11.2	9.6	0.0418	6.7	5.5	0.0086	4.7	3.8	0.0051
1988	12.3	10.6	0.0563	7.4	6.0	0.0115	6.1	4.0	0.0073
1989	13.0	11.3	0.0693	7.8	6.3	0.0131	6.7	4.4	0.0096
1990*	13.5	12.0	0.0768	8.0	6.6	0.0142	6.9	4.9	0.0104
1990#	14.2	12.0	0.0877	9.0	6.6	0.0172	7.5	4.9	0.0117
Year	<i>Fraxinus mandshurica</i>			<i>Ulmus pumila</i>			<i>P. simonii x canadensis</i>		
	Diameter /cm	Height /m	Volume /m³	Diameter /cm	Height /m	Volume /m³	Diameter /cm	Height /m	Volume /m³
1986	0.1	1.5	0.0002	3.3	3.5	0.0020	1.3	2.5	0.0002
1987	0.4	2.0	0.0004	4.7	4.0	0.0035	2.4	4.4	0.0009
1988	1.2	2.5	0.0009	6.5	4.3	0.0067	2.9	5.5	0.0024
1989	1.9	3.3	0.0013	7.3	4.5	0.0089	3.8	6.0	0.0038
1990*	2.7	3.5	0.0018	7.8	4.8	0.0099	4.2	6.3	0.0051
1990#	3.0	3.5	0.0020	9.1	4.8	0.0132	4.7	6.3	0.0062

Note : \*:inside bark (I.B); # : outside bark (O.B.).

**Table 4. Growth data of *P. simonigra* on different soils**

Year	Deep columnar soda- meadow-alkali soil			Alkalized meadow soil			Medium columnar soda- meadow-alkali soil		
	Diameter /cm	Height /m	Volume /m³	Diameter /cm	Height /m	Volume /m³	Diameter /cm	Height /m	Volume /m³
1986	7.6	8.60	0.0164	8.0	9.60	0.0226	3.1	4.50	0.0030
1987	8.5	9.60	0.0244	8.5	10.60	0.0275	3.6	5.00	0.0039
1988	9.3	10.60	0.0323	8.9	10.86	0.0322	4.5	5.50	0.0060
1989	10.0	11.06	0.0301	9.1	11.09	0.0355	4.9	6.00	0.0074
1990(I.B.)	10.5	11.52	0.0464	9.6	11.34	0.0398	5.3	6.02	0.0086
1990(O.B.)	11.0	11.52	0.0517	10.0	11.34	0.0434	5.7	6.02	0.0100
Age		11			11			10	

**Table 5. The above-ground biomass and leaf area of *P. simonigra***

Soil	No. of plot	Age	Stem	Bark	Branch	Leaf	Total	Leaf area index
Alkalized meadow soil	1	11	21.52	2.95	4.64	2.57	28.73	3.72
Deep columnar soda-meadow-alkali soil	6	10	14.67	2.16	6.68	1.21	22.56	2.02
Alkalized meadow soil	4	11	13.03	2.01	4.57	1.99	19.58	1.33
Medium columnar soda-meadow-alkali soil	3	10	7.01	0.83	1.79	1.21	9.01	0.74

biomass and leaf area on the soil of soda-saline-alkali.

## Conclusion and discussion

Plantations can be grown and established on the soil of soda-saline-alkali with the soil condition of pH-value 8.5~9.6, salinity 0.1%~0.3%, sodiumionized ratio 16%~51 % and normality ratio of saline base  $\text{Na}^+/(Ca^{++} + Mg^{++}) > 4$ . On the deep columnar soda-meadow-alkali soil, the order of tree volume increment is *P. simonigra* > *S. matsudama* > *U. pumila* > *P. simonii x canadensis* > *A. negundo* > *F. mandshurica*. *P. simonigra* grows very well on the all kinds of soda-saline-alkali soils except on the alkali spot with the worst soil condition. *P. simonigra* is a good tree species for planting on the soil of soda-saline-alkali. Its growth is not very different from that of popular in protective plantations on the other kinds of soil (Jiang et al 1990). Fertilizing with organic manure is the effective measures to increase the tree increment,

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